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Analysis of Barriers in Implementing Quality Management Initiatives in MSME Label Printing Firms for Sustainable Performance Improvement

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Abstract
Quality is essential in today's competitive market to ensure customers are happy; recent research shows that about 90% of customers think quality is just as important as price when purchasing. Total quality management (TQM) has been a boon to the economies of many countries. Different tools and methods are used in TQM to give customers the best quality. However, there are some challenges that manufacturing organizations face when implementing these tools. Much research has been done on MSME sector, so far as label manufacturers are concerned, there has yet to be any research on a national or international level. In this study, we found 66 barriers to programs to improve quality in the label printing industry. We have used fuzzy MICMAC analysis and total interpretive modeling (TISM) to make a structural model. Our research paper provides an easy-to-use methodology and critically analyses the biggest obstacles to the successful application of TQM in the flexographic printing industry. Our research identified ten issues with the implementation of TQM in this industry. The paper has identified the interdependencies of the above variables. The findings of this research will aid in future planning, particularly in E-commerce and the pharmaceutical industry, where proper label printing is crucial.

Keywords- TQM, Fuzzy-TISM, MICMAC, Barriers.

1. Introduction

Manufacturing has changed exponentially between the first industrial revolution and today's globalization and competition. Enterprises need help implementing these developments (Sahoo and Yadav, 2018). As the world improves, buyers' quality expectations alter. Customers now like eco-friendly products, which may cause the company to change its existing business model. Thus, they prioritize client happiness to suit their needs and maximize profit (Swarnakar et al., 2020). To compete in such a harsh climate, Indian MSME firms must step up and embrace numerous quality improvement measures (Herzallah et al., 2014).

Like any other manufacturing company, small and medium-sized enterprises (MSME) that print labels have been affected by the growth of computers and technology. Recent advancements in technology have changed how these companies work. Now, there is less manual work and more automation. Digital, offset, and flexographic printing techniques use much technical power. Flexography is the most common way to print labels, so it is well known. Flexographic printing is the most preferred type of printing technology due to its continuous process functionality, technology enhancement for non-porous substrates, and manufacturing flow (Mittal et al., 2021). Its popularity has also grown a lot in recent years. Technology changes significantly affect the flexographic printing markets, which also affects the companies that make equipment and supplies. These improvements include better digitization, automation, and inline finishing that lower costs and consider changing market needs.

Given that the equipment's quality is improving and digitalization is still going on, flexo remains the most cost-effective way to print medium to long runs. In addition to more hybrid and purpose-built press configurations, these projects include developing presses, inks, anilox rollers, plates, sleeves, and automation and control for the process. These efforts aim to improve quality while reducing the need for trained workers, which is becoming more challenging to find.

In the modern world, label printers are termed "label converters" as they do not just print the labels but provide services beyond that. Converting goes hand in hand with flexographic printing. A primary label-converting machinery setup could consist of the flexographic press alongside a winding/unwinding machine. Supporting equipment may include die-cutters and foil stamps. These ensure that labels of different sizes, layouts, and substrates can be dealt with accurately and quickly while maintaining the required quality (Machinery Ltd, n.d.). Label converters also offer consultation services to their customers, offer expertise and provide services such as lean manufacturing and processes that are good for the environment (labels and labeling). Despite these technological advances, which help flexographic printing grow, other things slow it down. According to the report, there is a chance that at least 50% of business improvement programs will fail over time and that up to 70% of them will not bring about the benefits they were supposed to (OECD, 1996). In the modern world, manufacturing organizations need not just to set goals, resources, and objectives to do well; they also need constant innovation and keep looking for growth opportunities (Bryson, 2018). Our research paper focuses on learning about the problems in the flexographic printing industry so that we can put our efforts where they are needed most. Labels and sustainable packaging are also global trends (Corporation, n.d.). When it comes to pharmaceuticals, the packaging industry has to find a balance between keeping patients safe and helping the environment. Our paper has analyzed these trends in sustainable printing. Flexographic printing has long been a go-to solution for many businesses, but it's changing swiftly to meet new consumer expectations, so there are some recent industry trends as discussed below:

- **(i)** **Automation:** Flexographic methods are used to demand skilled operators for high-quality results. Automation is becoming more common for presses due to process and plate preparation advances. This led to a broader fixed color palette, reducing ink, plate changes, and waste and improving products.
- **(ii)** **Addresses Operator Skill Gap:** Many manufacturers automate and digitize key functions by changing processes and production lines. The improved automated workflow reduces operator interaction with the presses.
- **(iii)** **Digitization Doesn't Threaten:** Digital printing is popular because companies can purchase lesser volumes and customize their products. New hybrid press units will guarantee industry prosperity in the future.
- **(iv)** **Market Declines:** On the downside, the decline in the readership of newspapers significantly affects conventional flexographic printing markets. While on the upside, E-commerce-driven packaging is a significant flexographic business activity with a large volume. Asia dominates packaging goods. Due to the economy and population, it is still increasing. Since economic expansion allows more individuals to buy American or European-branded items, consumer goods activity is up.
- **(v)** **Non-Toxic, Fast-Drying Inks:** It employs non-toxic inks and dries quickly. Flexographic printing is preferred in many industries, including food packaging.

(vi) Consistent Products: This industry can make millions of photos from one template, which is excellent.
(vii) Solid-color Printing Improvements: Flexographic printing's ink control methods allow it to print solid colors on various surfaces.

As shown above, the flexographic industry is undergoing many changes. Digitization and process automation are key industry trends. But specific barriers affect the adoption of these advancements.

2. Literature Review

2.1 Importance of Quality Management

Nowadays, it is almost impossible for manufacturing and service organizations to ignore the term "quality management," which refers to various plans and management measures that can be implemented to improve quality, reduce costs, promote productivity, and enhance corporate performance competitiveness (Tan and Goh, 2017). Quality management or quality improvement is vital for the success of any organization. It results in superior quality products and services to the customer, which is essential for the customer's satisfaction, and eventually, it results in the firm's goodwill. Quality control initiatives implementation in manufacturing organizations starts from receiving the raw material from the supplier to manufacturing the finished product (Delgado et al., 2010; Swarnakar and Vinodh, 2016; Jain and Ajmera, 2020; Swarnakar et al., 2020). However, there are specific challenges that organizations are facing in implementing these quality improvement initiatives.

2.2 Barriers to the Implementation of Quality Management Programs

Various authors in the contemporary world discuss the challenges that arise during recent quality improvement programs like Lean, TQM, etc. (Antony et al., 2007; Jain et al., 2018; Lamba and Singh, 2018; Kumar et al., 2020). They have proved that MSMEs could not adopt all quality improvement initiatives for various reasons. For successfully implementing TQM practices, the role of senior management commitment is investigated by several authors, such as (Soltani et al., 2008; Zhang et al., 2017; Kumar et al., 2020). In addition, the authors also determined reasons for a low commitment from top management. There is the likelihood of struggle with financial, technical, and operational constraints in micro, small, and medium-sized enterprises, which may be amplified further by several obstacles, like human resources deficiencies, and lack of technical and managerial expertise (Azyan et el., 2017). Unfortunately, it results in ad hoc adoption of individual practice due to insufficient expertise. Antony et al. (2017) discuss the importance of strategic-based factors which influence growth; while, ainulazyan has also identified a strategic approach as the significant barrier to the successful implementation of QM initiatives. Suppliers also act as an essential factor in producing good quality products as good quality of the product is ensured only when we use superior quality raw materials. While maintaining the quality of products, the importance of supplier-related issues is highlighted by Haleem et al. (2012), Luthra et al. (2015) and Piercy and Rich (2015). There is massive pressure on manufacturing firms from government agencies, media, consumers, environmental and NGOs, and other stakeholders to incorporate quality and environmental management practices into their business (Bansal and Clelland, 2004). However, environmental quality cannot be ignored while maintaining the product's standard, as both product and environmental quality are critical for the welfare of society (OECD, 1996). There are well-planned strategies and policies to integrate ecological and quality improvement strategies in the world's leading economies. However, in India, a developing economy, the implementation of these integrated programs is in its initial stages due to the lack of awareness, especially in SMEs, as well as due to limited resources and loopholes in government policies (Swarnakar et al., 2020). Organizations will never adopt sustainable practices due to the absence of such financial support (Govindan et al., 2014). Positive association of TQM and various performance outcomes such as financial, businesses well with human outcomes such as customer satisfaction, employee satisfaction, and supplier relationship. It can be referred back to the works of (Brah et al., 2000; Mehra and Ranganathan, 2008), etc. (Zvonkina et al., 2014) discussed the nature of inks as a barrier in the printing industry, harmful effects of exposure of workers to the toxic chemicals beyond the permissible limit acts as a barrier to this industry (labels and labeling). Lipiak (2017) discussed that the cleaning procedures in the flexographic printing industry are not standardized. Muthamma et al. (2021) encouraged the use of water-based inks in place of chemical-based ones. Further barriers to the MSME firms working in this industry are discussed below. In this paper, we have identified sixty barriers (Table 1) from an extensive literature survey and grouped these barriers into ten major categories, an analysis of which can act as a boon for organizations that have implemented specific quality improvement programs or are planning to implement them

Table 1. Barriers in the flexographic printing industry.

Main group	Subgroup	Reference	Description
Top management ownership and commitment.	Ineffective leadership	Ngai and Cheng (1997), Tamimi and Sebastianelli (1998), Kumar et al. (2020)	Lack of top management commitment and ownership is a barrier because it fails in TQM efforts.
	Lack of visionary leadership	OECD (1996), Ngai and Cheng (1997), Kaswan and Rathi (2021)	The leaders of the MSME firms do not have a good vision or clear objectives while implementing the new quality initiatives.
	Less formal training Of employees	Ngai and Cheng (1997), Zhang et al. (2017)	Poor training and education on quality create the inappropriate problem identification and its solution lead to the failure of the quality improvement program.
Lack of standard operating procedures.	Poor job descriptions	Zhang et al. (2017)	These firms lack proper job descriptions, leading to workplace miscommunication and confusion. It makes people feel they don't know what is expected of them
	lack of process standardization	BarTender (n.d.)	In this industry, it isn't easy to standardize the processes due to the complexity of flexography
	Improper ink management	Systems Inc. (n.d.)	The consistency of inks used in the flexographic printing industry varies.
	Lack of standard cleaning procedures	Zhang et al. (2017), Singh et al. (2021)	Cleaning procedures in this industry are not standardized.
Human resource issues	Low skill employees	Ngai and Cheng (1997), Mathiyazhagan et al. (2013), Lamba and Singh (2018)	Employees working in MSME firms do not have the proper skills for a specific job to run the flexographic printing process smoothly. One needs to be an expert in the respective field.
	Lack of proper training and education – self-learned	Mathiyazhagan et al. (2013), Singh et al. (2021)	Most of the employees do not have any proper certifications. They are self-learned, i.e., they learn their work just by practice
	Improper registration	Discussions with industry experts	In the flexographic industry, registration disturbs periodically
	job insecurity among employees	Mathiyazhagan et al. (2013), Jain et al. (2018)	Employees of the firm are not permanent, which is why they fear losing their job
	Mishandling of ink	Industries (n.d.)	In the flexographic printing industry, mishandling of ink creates around 50 percent problems
	Lack of commitment and participation from employees	Amar and Zain (2002), Mathiyazhagan et al. (2013)	In these organizations, there is a lack of commitment and involvement among employees.
	Resistance to change	Ngai and Cheng (1997), Zhang et al. (2017), Kumar et al. (2020)	Often employees suffer from language barriers or illiteracy and are not interested in adopting new ideas, skills, knowledge, and culture, while many educated and specialized employees resist changing the process as they are not flexible with the quality of work.
	Exposure of workers to the chemicals in workplace	Partners (n.d.)	Exposure of workers to more than the permissible limit affects the quality of printing in this industry.
	Lack of employee welfare policies	Mathiyazhagan et al. (2013)	These organizations lack welfare policies to provide benefits and facilities so that employees can work in a better environment
	Low safety standards	Discussion with experts	safety standards are not up to the mark in the flexographic printing industry, which acts as a barrier
	Stretched working hours	Ngai and Cheng (1997), Talib (n.d.)	Sometimes employees have to work overtime which decreases the efficiency

Table 1 continued…

Resource constraints	Financial constraints	Machinery Ltd (n.d.)	High cost of flexo printing machines.
	Time constraints	Tamimi and Sebastianelli (1998)	Quality improvement programs require time sometimes; it is not possible to adopt them because of the unavailability of time
	Low production volumes	Bag et al. (2020), Talib (n.d.)	Most of the MSMEs' production volumes are low because they are working on a small scale
	limited cash flows	Singh et al. (2021)	Most MSMEs have limited amounts of cash to run the business smoothly.
	Limited infrastructure	Discussion with experts	Most MSMEs have small facilities, and flexographic machines need huge space, creating problems in smoothly running the business.
	Limited collateral security	OECD (1996)	MSMEs lack giving something as collateral security to get a loan for some investment.
	Insufficient external funding	Kumar et al. (2020)	Most MSMEs depend on internal funding as people wish to give money to an established business.
Lack of strategic approach	unclear objectives	Ngai and Cheng (1997), Singh et al. (2021), Talib (n.d.)	Sometimes the objectives of the quality improvement program are not evident among the firm's employees.
	Lack of a quality policy –Strategic objectives linking weakly with quality improvement projects	Jain et al. (2018)	In many of these organizations, there is a lack of quality policy.
	Assuming quality initiatives as a measure for quick cost reduction/revenue augmentation	Ngai and Cheng (1997)	Employees and management of these organizations think of quality initiatives as a measure to get instantaneous results in the form of cost reduction or revenue generation
	Quality improvement projects lack a continuous improvement approach	Singh et al. (2021), Aboelmaged (2011)	It is commonly perceived that quality improvement programs do not show continuous process improvement.
	Unclear financial outcomes and associated risks	Bag et al. (2020)	The financial outcomes and risks associated with the performance improvement programs are not evident among these organizations
	Communication gaps at all levels, vertically and horizontally	Ngai and Cheng (1997), Bag et al. (2020), Talib (n.d.)	Communication within departments is an essential factor for the overall growth of the business lacking which acts as a barrier
	No quality culture	Antony et al. (2017)	Small organizations in a country like India do not have a specific quality culture.
Readiness for QM initiatives	Resources and skills to facilitate implementation	Ngai and Cheng (1997)	These organizations lack human, technological, and financial resources to facilitate the implementation of quality improvement initiatives
	Project management tools, process improvement toolset, and change management tools.	Antony et al. (2017), Bag et al. (2020)	Due to their size, these organizations suffer from project management and process improvement tools.
	Project selection and prioritization	Antony et al. (2017), Bag et al. (2020)	The management does not have any proper methods for the selection of projects to be implemented.
	Measurement methods	Al-Zamany et al. (2002)	There are no proper measurement methods, i.e., employee satisfaction, customer feedback, etc.
	Data recording and management	Swarnakar et al. (2020), Singh et al. (2021)	In such small organizations, data is not adequately recorded and managed
	Problem-solving tools	Bag et al. (2020)	lack of various problem-solving tools.
	Flexibility in operations and overall	Bastas and Liyanage (2018)	these organizations are not flexible at all
	Lack of benchmarking standards	Ngai and Cheng (1997), Singh et al. (2021)	Small-scale organizations do not have proper benchmarking standards.
	Less awareness and access to the support available from external sources, such as Govt policies and schemes	Al-Zamany et al. (2002)	because of their small size, these organizations do not get help from external organizations.
	Poor information management	Singh et al. (2021)	information sharing is not adequately managed among all the levels.
	Supply chain partners' cooperation and involvement	Yellinedi (2017)	supply chain partners, like manufacturers, retailers, etc., do not cooperate.
	Risk assessment	Discussion with experts	No proper risk assessment methods.

Table 1 continued…

Supplier issues	Coordination issues with suppliers	Mathiyazhagan et al. (2013), Jain et al. (2018)	there are no long-term relationships with customers.
	Lack of supplier focus on quality	Group (n.d.)	The flexographic industry suffers if the suppliers of the ink, plate, etc., are not reliable
	Conflicting objectives	Yellinedi (2017)	sometimes various improvement programs have conflicting goals.
	Replenishment delays	Mathiyazhagan et al. (2013), Yellinedi (2017)	these firms have long waits for their inventory to get replenished.
Customer issues	Transactional relationships	Mathiyazhagan et al. (2013)	transactional relationships between the suppliers and customers are not properly managed
	Competitive and price-sensitive market	Yellinedi (2017)	frequently changing market scenarios hinder the implementation of performance improvement programs.
	Lack of structured feedback mechanisms	Zhang et al. (2017)	there is no customer feedback system within these firms
	poor supply chain focus	Mathiyazhagan et al. (2013)	MSME firms work on one-to-one relationships instead of the whole supply chain.
	Demand uncertainty	Swarnakar et al. (2020)	As these firms do not have long-term relationships with their clients, so there is a demand for uncertainty
	Payment delays	Mathiyazhagan et al. (2013)	Lengthy waiting time between receiving a bill and paying it.
	lengthy order to cash cycle	Mathiyazhagan et al. (2013)	Order-to-cash cycles are generally eight-stage processes, including order management, invoicing and payment collections, etc.
	coordination issues	Bastas and Liyanage (2018), Swarnakar et al. (2020)	lack of coordination within the various departments of the firm and between suppliers and customers
Environmental issues	High waste generation in machine setups	Aboelmaged (2011)	while setting the machine before printing, a vast amount of substrate gets wasted to get the correct structure of registration marks, etc.
	poor waste disposal	Bastas and Liyanage (2018)	There are no proper methods of waste disposal which result in environmental harm
	Washout solvents	Discussion with experts	Some chemical solvents used in the flexographic printing industry are unsafe for the environment.
	Conformance to Govt. waste management policies	Mathiyazhagan et al. (2013)	frequently changing government policies regarding waste disposal
Technology adoption issues	High cost of technology	Zhang et al. (2017)	Advanced technologies in the field are available at a higher cost
	Skill unavailability for technology adoption and implementation	Mathiyazhagan et al. (2013)	as technologies advances at a rapid rate, there is a problem in technology adoption and implementation
	Long breakeven time	Al-Zamany et al. (2002)	It takes a longer time to give a return back investment cost
	technology obsolescence cost	Swarnakar et al. (2020)	Most of the technology becomes obsolete after a few years, which is of no use
	Digitalization of workflow	Zhang et al. (2017)	employees of the firm do not know about information technology
	Fear of job loss	Ink World (n.d.)	As more and more processes are becoming automated in flexographic printing, employees fear job loss.

2.3 Application of TISM for Identification of Barriers

Interpretive structural modeling is a decision-making technique involving multiple criteria to structure and impose order and direction on complex variables. Mathiyazhagan et al. (2013) gave an ISM approach for analyzing the barriers. The formed model depicts a complicated issue's structure (Jain et al., 2018). To overcome the shortcomings of ISM, an extension in the form of total interpretive structural modeling is developed. The theoretical foundation proposed by Haleem et al. (2012) has been built on the ISM methodology (Warfield, 1974).

Dhir in 2019, developed a TISM model for strategic thinking enablers. Yadav and Sagar (2015) gave a TISM model for the Indian automobile manufacturing enterprise. Prasad and Suri (2011) have utilized TISM to model higher technical education. Jena et al. (2016) identified the critical success factors of smartphone manufacturing with the help of the TISM model. Zhang et al. (2017) model the lean barriers for successful lean implementation. Lamba and Singh (2018), it has been used to model the Big data enablers for operations and supply chain management. Kumar et al. (2020) studied the barriers to total quality management for sustainability in Indian organizations.

Fuzzy TISM is an extension of TISM in which fuzzy set theory is integrated with traditional TISM to overcome the vagueness and bring crispness to decision-makers opinions. It also considers the degree of influence of one variable over another, which was earlier based on 0 and 1 only (Khatwani et al., 2015) utilized fuzzy TISM to model the big data enablers of operations.

3. Research Gaps

A considerable amount of literature is available on barriers to service quality. Manufacturing quality lacks the amount of research it deserves to analyze this industry's barriers. In the literature, there are research papers focusing on MSMEs; however, so far as label converters or label manufacturers are concerned, there is no research at the national or international level. This paper tried to bridge this gap by analyzing the barriers to quality improvement programs in the flexographic printing industry. There is an urgent need to do this research as E-commerce companies depend entirely on RFID technology of reading labels for logistics and order fulfillment. The pharmaceutical industry also needs to be very careful of faults in label printing.

4. Methodology

4.1 Interpretive Structural Modeling

Interpretive structural modeling, which is an iterative process, was proposed by Warfield (1974). It structures interrelated variables affecting a system into a comprehensive model. The concept of ISM is to utilize an expert's knowledge and practical experience to decompose a complex system into several subsystems (elements) and build a multilevel structural model. Several steps involved in the ISM process can be found in Warfield's seminal work (1974). The ISM methodology aids in imposing order and direction on the complexity of relationships between system elements (Warfield, 1974). Sharma and Gupta (1995) used the ISM methodology to create a hierarchy of actions needed to achieve India's future waste management goal. The ISM technique utilized by Kumar et al. (2020) to model the interrelationship within factors for adopting lean manufacturing. ISM is used in a variety of applications, including decision support systems, waste management (Sharma and Gupta; 1995), product design (Lin et al., 2006), supply chain management (Kannan et al., 2009), value chain management (Mohammed et al., 2008), world-class manufacturing (Haleem et al., 2012), and recently it is extensively being used as a modeling technique in the fields of total quality management and lean (Ngai and Cheng, 1997; Salaheldin, 2009; Zhang et al., 2017).

4.2 Fuzzy Theory

Zadeh introduced the concept of fuzzy theory in 1965 to handle the data more effectively. In fuzzy theory, the fuzzy set A is the subset of the universal set X, which a membership function can define. It is used to provide crispness in vague, uncertain, and ambiguous situations. Every element in fuzzy theory belongs to a concept class to a partial degree, i.e.,

$$C: X \rightarrow [0, 1], C(x) = c \in [0, 1], x \in X \tag{1}$$

where, $C(X)$ is the membership assignment of an element "X" to a concept class C, the membership function $C(X)$ of the triangular fuzzy member can be defined as follows. The fuzzy triangular numbers can be characterized by the triplet (l, m, u). Where l, m, and u are the lower, middle, and upper weight of the triangular fuzzy number $\hat{C}$, the graphical representation and membership function of the triangular fuzzy number is shown in Figure 1.

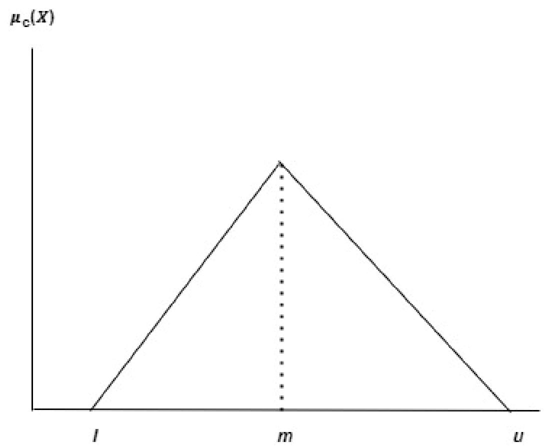

Figure 1. Triangular fuzzy number.

$$\mu_C(X) = \begin{cases} 0 & if\ X \leq c \\ \frac{X-c}{m-c} & if\ c < X \leq m \\ \frac{b-X}{b-m} & if\ m < X < b \\ 0 & if\ X \geq b \end{cases} \tag{2}$$

The theorems which have been utilized in this paper for dealing with fuzzy numbers are discussed here in brief:

Theorem 1. Operations on fuzzy numbers.
Let the two triangular fuzzy numbers be:

$\hat{C}_1 = (l_1, m_1, u_1)$ and $\hat{C}_2 = (l_2, m_2, u_2)$ The Addition operation of $\hat{C}_1$ and $\hat{C}_2$ is again a triangular fuzzy number and is denoted by

$$\hat{C}_1 \oplus \hat{C}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{3}$$

Theorem 2. Here, we have used the converting fuzzy data into crisp score (CFCS) method given by Opricovic and Tzeng (2003) for the defuzzification.

Let $\hat{C}_k = ((l_k, m_k, u_k); k = 1, 2, .., n)$ be the positive triangular fuzzy number, then'C_K^{crisp}' denotes the crisp value.

4.3 Fuzzy TISM

Haleem et al. (2012) proposed an extended version of ISM in the form of TISM. TISM is known to be a better version of ISM as nodes and links are interpreted in the digraph. Although TISM overcomes the limitations of ISM to a greater extent, it still suffers from the shortcoming of explaining the relationship in binary variables 0 and 1 only. Various symbols that have been used to assign the relationship between the variables *i* and *j* are shown in Table 2.

Table 2. Contextual relationship.

Symbol	Contextual relationship
V	When variable '*i*' influences variable '*j*'.
A	When variable '*j*' influences variable '*j*'
X	When variables '*i*' and '*j*' influence each other
O	When variables '*i*' and *j* are not related

Since the relationship between the variables can vary from Very High influence, High influence, Low influence, Very Low influence, and no influence(Lamba and Singh, 2018), the integration of fuzzy theory with TISM provides flexibility to the decision-maker (Khatwani et al., 2015). In this methodology, the responses got categorized into five linguistic variables, such as No impact, Very Low Impact (VL), Low Impact (L), High Impact (H), and Very High Impact (VH), as shown in Table 3.

In our study, 66 barriers influencing the quality management initiatives in MSME label printing firms are classified into ten groups. We analyze the interrelationship between these ten main categories of barriers in MSME label printing firms.

Table 3. Linguistic scale for the influence.

Linguistic Term	Fuzzy Value	Notation
Very high impact	(0.75, 1.0, 1.0)	VH
High impact	(0.5, 0.75, 1.0)	H
Low impact	(0.25, 0.5, 0.75)	L
Very low impact	(0, 0.25, 0.5)	VL
No impact	(0, 0, 0.25)	NO

The basic concepts of the fuzzy TISM methodology are:

Step1: Decision-making process initialization
Explaining decision goals is the first step in the decision-making process, followed by collecting crucial information and identifying the best possible alternatives.

Step 2: Criteria selection
At this stage, a set of criteria is established. These criteria may influence the other criteria or may get influenced by them. We incorporate a fuzzy linguistic scale for group decision-making to deal with the uncertainty in the experts' decisions.

Step 3: Structural self-interaction matrix (SSIM) creation
A group of experts was called to gather information about the interrelationship between various criteria $C = C_i$, where, i=1, 2, …, n to be filled in SSIM.

Respondents used a combination of symbols V, A, X, and O as well as linguistic terms, i.e. (VH, H, L, VL, NO) to demonstrate the relationship between the criteria.

Step 4: Aggregated SSIM and the final fuzzy reachability matrix determination

In this case, the Mode was used to aggregate responses from individual experts, resulting in an aggregated SSIM matrix. The aggregated SSIM matrix is then converted into a fuzzy reachability matrix. Previously defined fuzzy triangular linguistic values replace the linguistic terms in the aggregated SSIM matrix. Consider the case where the (*i*, *j*) entry in a structured self-interaction matrix (SSIM) is V(VH); we will denote it as (0.75, 1, 1) and the (*j*, *i*) entry as (0, 0, 0.25), which are fuzzy numbers corresponding to linguistic variables.

Step 5: Calculating the driving power and dependence powers for fuzzy MICMAC analysis

Generate a fuzzy reachability matrix from the aggregated fuzzy SSIM matrix and calculate driving and dependence powers. The steps used in the calculations of crisp values of driving and dependence power (Table 11) can be referenced (Jain et al., 2018).

Step 6: Reachability matrix partition using relation and level partition

Partition the reachability matrix and check the transitivity in the table.

Step 7: Creating digraphs

Create a digraph to visualize the level of influence.

4.4 Analysis of Barriers Affecting Label Printing Firms Using Fuzzy Total Interpretive Structural Modeling

Following are the steps taken to analyze the barriers:

Step 1: Initialize the decision-making process

A group of five experts was called to gather the responses. Two experts are from MSME firms working on flexographic label printing, and three experts are from prestigious Indian institutes, having a good research profile to gather their responses regarding the relationships between variables.

Step 2: Criteria selection

Sixty-six barriers affecting the quality improvement initiatives in the MSMEs dealing in flexographic printing are collected from the literature, which is further clubbed into ten influential groups with the help of decision makers.

Step 3: Creating aggregated SSIM and final fuzzy reachability matrix

Table 4, 5, 6, 7 and 8 shows the responses of experts in the form of a structural self-interaction matrix (SSIM) aggregated SSIM matrix is made by taking the modal value of the expert's opinion (Table 9)

Table 4. SSIM of expert 1.

	B10	**B9**	**B8**	**B7**	**B6**	**B5**	**B4**	**B3**	**B2**
Top management ownership and commitment(B1)	V(H)	V (VH)	X(L,VH)	V(VH)	V(VH)	V(VH)	X(H,VH)	X(VH,L)	V(VH)
Lack of standard operating procedures(B2)	V(L)	X(H)	O	V(L)	X(L)	X(H,L)	A(VH)	X(VH)	
Human resource issues(B3)	X(L)	O	V(L)	V(VL)	X(L,H)	A(L)	A(VH)		
Resource constraints(B4)	V(VH)	X(H,L)	A(L)	V(H)	V(VH)	X(H,L)			
lack of strategic approach (B5)	V(VH)	O	X(L,VL)	X(L,H)	A(H)				
Readiness for QM initiatives(B6)	V(H)	O	X(L)	X(L)					
supplier issues(B7)	X(L,H)	X(L)	A(L)						
Customer issues(B8)	X(H,VH)	X(L,H)							
Environmental issues(B9)	O								
Technology adoption issues(B10)									

Table 5. SSIM of expert 2.

	10	9	8	7	6	5	4	3	2
Top management ownership and commitment(B1)	V(L)	V (VH)	X(L,VH)	X(VH,VL)	V(H)	V(VH)	X(H,VH)	X(H,L)	V(H)
Lack of standard operating procedures(B2)	V(L)	V(H)	O	V(VL)	V(L)	X(L,H)	A(VH)	X(H)	
Human resource issues(B3)	X(H,L)	O	V(L)	V(L)	X(L)	A(L)	A(H)		
Resource constraints(B4)	V(H)	X(H,L)	X(L)	V(L)	V(VH)	X(H,L)			
lack of strategic approach (B5)	V(H)	O	X(L,H)	X(L,H)	A(H)				
Readiness for QM initiatives(B6)	X(H,L)	O	X(L)	X(L,H)					
supplier issues(B7)	X(H)	X(L)	A(VL)						
Customer issues(B8)	X(H)	X(H,L)							
Environmental issues(B9)	O								
Technology adoption issues(B10)									

Table 6. SSIM of expert 3.

	10	9	8	7	6	5	4	3	2
Top management ownership and commitment(B1)	V(VH)	V(VH)	V(VH)	X(VH,VL)	V(VH)	V(H)	A(VH)	X(VH,L)	A(H)
Lack of standard operating procedures(B2)	X(L,VL)	A(H)	V(VL)	O	A(VH)	O	A(VH)	X(VH,H)	
Human resource issues(B3)	X(H,L)	O(NO)	V(L)	O(NO)	X(L)	A(H)	X(H)		
Resource constraints(B4)	A(VH)	X(H,L)	O(NO)	V(L)	V(VH)	X(H)			
lack of strategic approach (B5)	X(H)	O(NO)	A(H)	O	A(L)				
Readiness for QM initiatives(B6)	X(H)	X(VL)	A(L)	X(H)					
supplier issues(B7)	A(H)	X(H)	O						
Customer issues(B8)	A(VH)	X(H)							
Environmental issues(B9)	X(VL)								
Technology adoption issues(B10)									

Table 7. SSIM of expert 4.

	10	9	8	7	6	5	4	3	2
Top management ownership and commitment(B1)	V(VH)	V (VH)	X(L,VH)	A(VL)	V(VH)	X(VH,VL)	X(VH,VH)	X(VH,L)	V(VH)
Lack of standard operaing procedures(B2)	V(L)	V(H)	O	V(L)	V(L)	X(L,H)	A(VH)	X(H)	
Human resource issues(B3)	V(H)	O	O	V(VL)	X(L)	A(L)	A(VH)		
Resource constraints(B4)	V(VH)	A(L)	X(L)	V(L)	V(VH)	X(H,L)			
lack of strategic approach (B5)	V(H)	X(VL)	X(L,H)	A(H)	A(H)				
Rediness for QM initiatives(B6)	V(H)	X(VL,VL)	X(L)	X(L,H)					
supplier issues(B7)	X(L,H)	X(L)	A(VL)						
Customer issues(B8)	X(H)	X(L,H)							
Environmental issues(B9)	O								
Technology adoption issues(B10)									

Table 8. SSIM of expert 5.

	10	9	8	7	6	5	4	3	2
Top management ownership and commitment(B1)	V(VH)	V(VH)	X(H,VH)	X(VH,VL)	V(VH)	V(VH)	X(H,VH)	O(NO)	V(VH)
Lack of standard operating procedures(B2)	V(H)	V(H)	X(VL)	V(L)	V(L)	X(L,H)	A(H)	X(H)	
Human resource issues(B3)	X(H,L)	V(VL)	A(L)	V(VL)	X(L,H)	A(H)	A(VH)		
Resource constraints(B4)	V(VH)	X(H)	X(L)	V(L)	V(VH)	X(H)			
lack of strategic approach (B5)	V(H)	V(VL)	X(L,H)	X(L,H)	A(H)				
Rediness for QM initiatives(B6)	V(H)	O	X(L)	X(L,H)					
supplier issues(B7)	X(L,H)	X(L,H)	A(VL)						
Customer issues(B8)	X(H)	X(L,H)							
Environmental issues(B9)	O								
Technology adoption issues(B10)									

Table 9. Aggregated SSIM matrix.

	B10	B9	B8	B7	B6	B5	B4	B3	B2
Top management ownership and commitment(B1)	V(VH)	V (VH)	X(L,VH)	X(VH,VL)	V(VH)	V(VH)	X(H,VH)	X(VH,L)	V(VH)
Lack of standard operating procedures(B2)	V(L)	V(H)	O	V(L)	V(L)	X(L,H)	A(VH)	X(H)	
Human resource issues(B3)	X(H,L)	O	V(L)	V(VL)	X(L)	A(L)	A(VH)		
Resource constraints(B4)	V(VH)	X(H,L)	X(L)	V(L)	V(VH)	X(H,L)			
lack of strategic approach (B5)	V(H)	O	X(L,H)	X(L,H)	A(H)				
Readiness for QM initiatives(B6)	V(H)	O	X(L)	X(L,H)					
supplier issues(B7)	X(L,H)	X(L)	A(VL)						
Customer issues(B8)	X(H)	X(L,H)							
Environmental issues(B9)	O								
Technology adoption issues(B10)									

And final reachability matrix is given in Table 10.

Table 10. Final fuzzy reachability matrix.

1	1	2	3	4	5	6	7	8	9	10
1	1	VH	VH	H	VH	VH	VH	L	VH	VH
2	NO	1	H	NO	L	L	L	NO	H	L
3	L	H	1	NO	NO	L	VL	L	N0	H
4	VH	VH	VH	1	H	VH	L	L	H	VH
5	NO	H	L	L	1	NO	L	L	NO	H
6	NO	NO	L	NO	H	1	L	L	NO	H
7	VL	NO	NO	NO	H	H	1	NO	L	L
8	VH	NO	NO	L	H	L	VL	1	L	H
9	NO	NO	NO	L	NO	NO	L	H	1	NO
10	NO	NO	L	NO	NO	NO	H	H	NO	1

Table 11. Fuzzy and crisp values of driving and dependence power.

Barrier	Dependence Power	Dependence Power Crisp	Driving Power	Driving Power Crisp
B1	(2.25, 3,5)	4.3	(6.25, 7.75, 8.5)	9.7
B2	(2, 2.5, 4.75)	4	(3.5, 4.5, 6.25)	6.4
B3	(2.5, 3.25, 5.25)	4.5	(1.5, 2, 4.25)	4.2
B4	(2.75, 3.5, 5.5)	4.7	(4.75, 6.25, 7.75)	8.2
B5	(2.75, 3.5, 5.5)	4.7	(3.75, 5, 6.75)	7
B6	(5, 6.75, 8.25)	7.1	(3, 4, 6)	6.1
B7	(4.25, 5.25, 7)	5.9	(2.25, 2.75, 4.75)	4.7
B8	(4, 5.25, 7)	5.9	(2, 2.5, 4.75)	4.7
B9	(5.75, 7.5, 8.5)	7.6	(3.5, 4.5, 6.25)	6.4
B10	(4.5, 5.75, 7)	6.2	(5.25, 7, 8.5)	9.2

Step 4: FUZZY MICMAC analysis based on crisp values of driving and dependence power

The fuzzy MICMAC analysis divides the variables into four groups. In this analysis, the relationship is not binary; instead, the variables have ambiguous relationships based on expert opinion. Cluster 1 comprises autonomous barriers with limited driving and reliance abilities. The dependent barriers with low driving but high dependence power is inside cluster 2. The linkage barriers with high driving and dependence powers are inside cluster 3. The independent barriers have high driving, but low dependence power is inside cluster 4. To successfully implement quality improvement initiatives focusing on sustainability, the firm must first analyze the driving barriers and then manage the dependent barriers as shown in Figure 2.

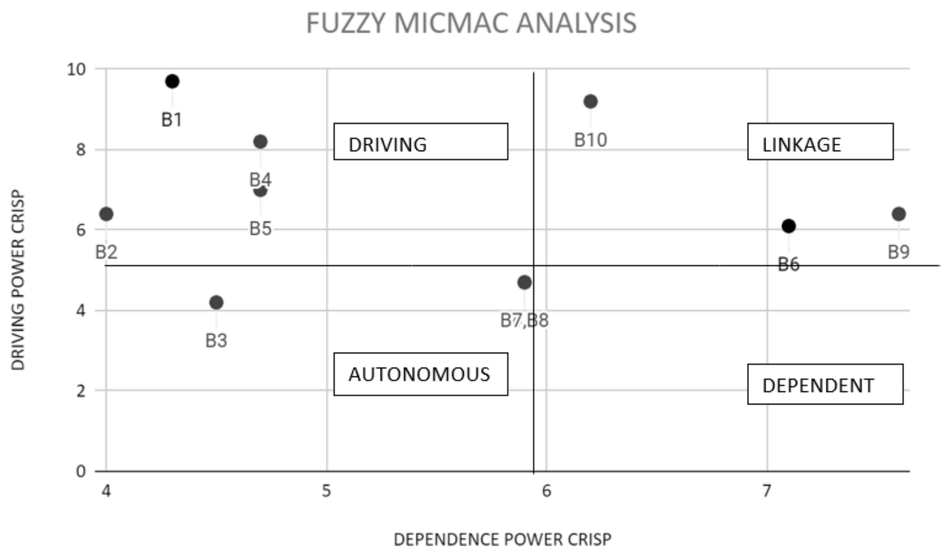

Figure 2. FUZZYMICMAC analysis.

Here the MICMAC analysis shows that three variables, i.e., B3, B7, and B8 come under the category of autonomous, i.e., they neither influence other variables nor themselves get influenced by others. Three variables, i.e., B6, B9, and B10, are linkage variables having high driving and dependence powers. Four variables, B1, B2, B4, and B5 are driving variables having high values of driving powers

The defuzzified driving and dependence power matrix are drawn with the help of the defuzzified reachability matrix (Table 12). It is obtained by replacing VH and H as one and the rest as 0 in the final fuzzy reachability matrix.

Table 12. Defuzified reachability matrix.

	1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	1	1	1	1	1	1
2	0	1	1	1	1	0	0	1	1	1
3	0	1	1	0	0	0	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1
5	0	1	0	0	1	0	1	1	0	1
6	0	1	0	0	1	1	1	1	0	1
7	0	1	0	0	1	1	0	0	0	1
8	1	1	1	1	1	1	1	1	1	1
9	1	1	0	0	1	0	0	1	1	1
10	1	0	0	0	1	1	1	1	0	1

Defuzified MICMAC analysis (Figure 3) reveals no variable in the autonomous category; two variables are in the dependent quadrant, three are linkage, and five are driving variables.

Step 5: Level partitioning from the reachability matrix
Table 13 shows the level partitions from iteration 1 to 5.

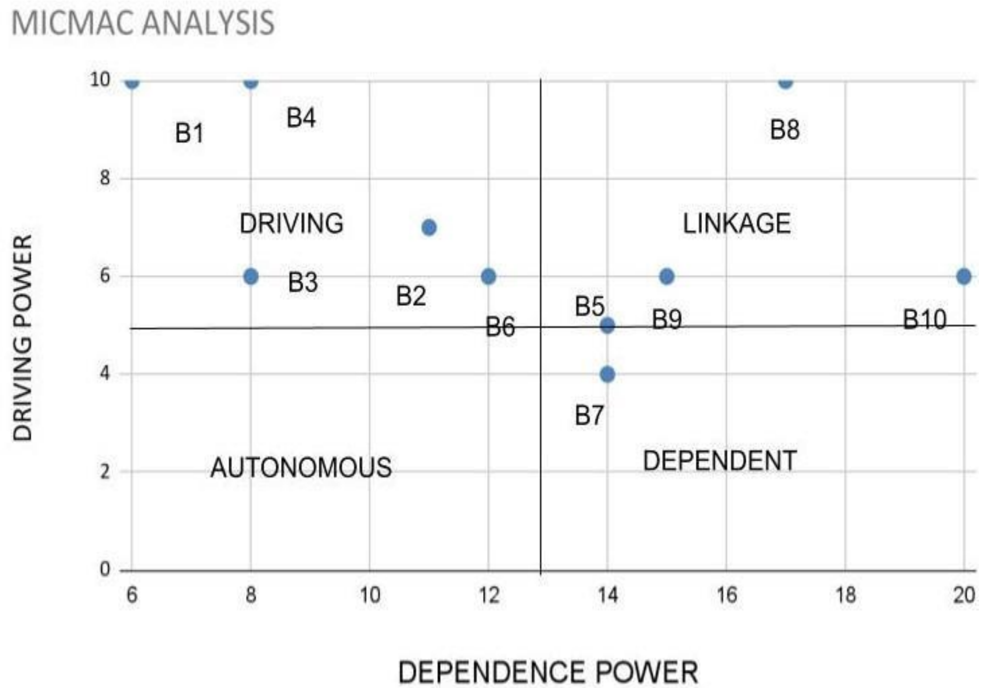

Figure 3. MICMAC analysis based on defuzified reachability matrix.

Table 13. Reachability matrix partition.

Barrier	Reachability	Antecedent	Intersection	Level
B5	2,5,7,8,10	1,2,4,5,6,7,8,9,10	2,5,7,8,10	1
B10	1,5,6,7,8,10	1,2,3,4,5,6,7,8,9,10	1,5,6,7,8,10	1
B2	2,3,4,8,9	1,2,3,4,6,7,8,9	2,3,4,8,9	2
B9	1,2,8,9	1,2,3,4,8,9	1,2,8,9	2
B6	6,7,8	1,6,7,8	6,7,8	3
B7	6	1,3,6,4,8	6	3
B3	3,8	1,3,4,8	3,8	4
B8	1,3,4,8	1,3,4,8	1,3,4,8	4
B1	1,4	1,4	1,4	5
B4	1,4	1,4	1,4	5

The following digraph (Figure 4) shows that top management ownership and resource constraints are at the bottom level of the digraph. Also, the MICMAC analysis shows that these two variables come under the driving quadrant, i.e., they have strong driving power. They directly or indirectly influence almost all of the variables. So, these two variables are most prominent, followed by human resource issues and customer issues, then readiness for QM initiatives and supplier issues on the next level, followed by lack of standard operating procedure and environmental issues and lack of strategic approach and technology adoption issues on the top.

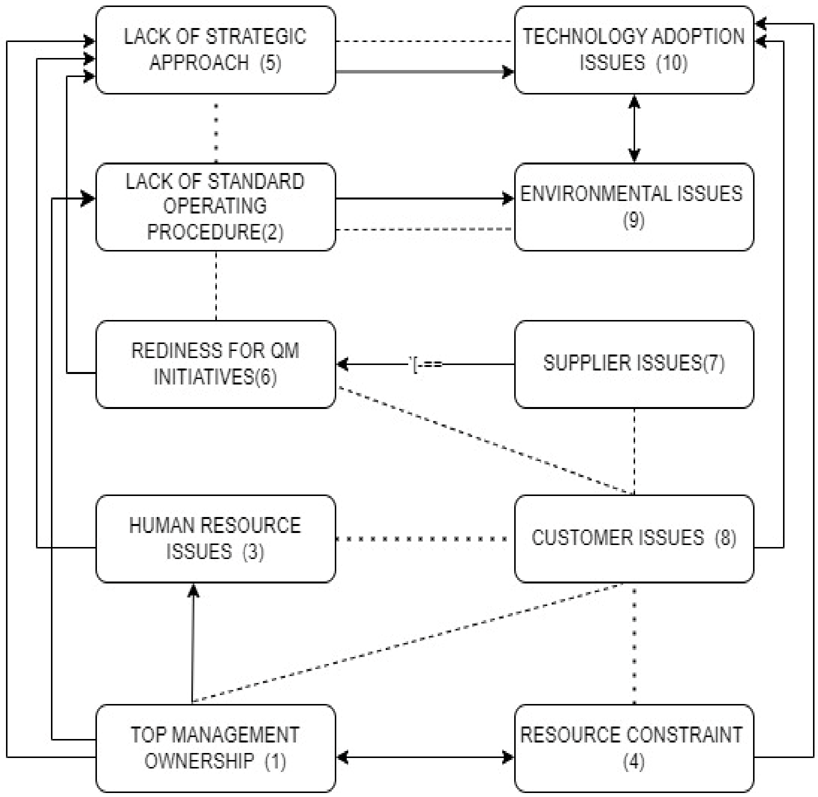

Figure 4. Digraph.

5. Results and Discussion

This research aims to identify the impediments to implementing quality management initiatives for the firm's long-term improvement. Mentioned barriers have been included in the current study due to their extensive identification as a barrier through literature review and connection with the research agenda. The hierarchical structure of these barriers aids in gaining a proper understanding and makes the prioritization process more competitive. To induce sensitivity in results, the current study employs fuzzy TISM methodology, which uses fuzzy sets for prioritizing the barriers that affect the implementation of quality improvement initiatives with a focus on sustainability. Ten obstacles to QM initiative adoption with sustainability considerations were dug out from the literature, and their interrelationships were obtained based on expert opinion. A model with five levels is built using fuzzy TISM methodology. This analysis revealed that top management ownership and commitment, as well as resource constraints, are the most prevalent since they have excellent driving power and can be seen at level one, followed by human resource issues and customer issues at level two. Readiness for quality management initiatives and supplier issues is placed at level three, followed by a lack of standard operating procedures at level four. All of the barriers are affected by the first-level barriers.

5.1. Contextual Relationship

The contextual relationship of one barrier over another is shown in Table 14.

Table 14. contextual relationship.

S. No.	Barrier	Contextual relationship	Interpretation
1.	Top management ownership and commitment	Barrier 1 influences barrier 3	Expert and well-educated management helps to settle down all the human resource issues
		Barrier 1 influences barrier 4	Lack of ownership and commitment in the top management may result in resource unavailability.
		Barrier 1 influences barrier 5	A firm lack in strategic approach if the top management is not committed.
2.	Lack of standard operating procedures	Barrier 2 influences barrier 9	lack of standard operating procedures creates environmental issues.
3.	Human resource issues	Barrier 3 influences barrier 5	Firms lack a strategic approach because the employees of the firm are not skilled
4.	Resource constraints	Barrier 4 influences barrier 1	Limited availability of resources affects the decision and commitment of top management
		Barrier 4 influences barrier 10	sometimes due to the unavailability of financial resources, we could not adopt the latest technologies in the field
5.	Lack of strategic approach	Barrier 5 influences barrier 10	a company without well-defined goals and objectives suffers a lot in the adoption of the latest technology
6.	Readiness for QM initiatives	Barrier 6 influences barrier 5	a firm that is not ready for quality management initiatives does not have well-defined business goals and strategies
7.	Supplier issues	Barrier 7 influences barrier 6	The adoption of QM initiatives in a firm depends a lot on the suppliers of the firm as a superior quality product can be made only with excellent quality raw material
8.	Customer issues	Barrier 8 influences barrier 10	sometimes certain technologies may harm customers
9.	Environmental issues	Barrier 9 influences barrier 10	Some latest technologies in the flexographic printing industry could not be adopted due to environmental concerns.
10.	Technology adoption issues	Barrier 10 influences barrier 9	After the adoption of specific technologies, we discover serious environmental issues.

6. Conclusion

The research work presented here is divided into two stages. In stage one, we have identified 66 barriers from an extensive literature survey and discussion with experts related to the quality improvement programs in the Indian MSME working on flexographic printing. The type of firms considered here dealing with the production of Lubricant Labels, Printed Stickers, Printed Labels, Cosmetic Labels, Printed Barcode Labels, Self-Adhesive Labels Printing Services, and much more. They are mainly providing their services for the pharmaceutical industry and E-commerce.

In the second stage, a TISM model with fuzzy MICMAC analysis is performed to analyze the barriers based on their driving and dependence powers. The fuzzy TISM technique enabled us to assess barrier interrelationships and depicted these in the TISM model. The results revealed that top management ownership and resource constraints are the most prominent barriers to the label printing industry. These two barriers have strong driving power and poor dependence power, so they influence other variables, do not get influenced by others, and are at the bottom hierarchy of the fuzzy TISM model. The organization's top management can decide the priority of the variables, which helps to stay focused to obtain desired results in enhanced productivity, flexibility, sustainability, and quality of the final product. Various sub-barriers of top management ownership and commitment, such as lack of visionary leadership, and less formal employee training programs, hinder business growth. Sub barriers of the group resource constraints include financial constraints, time constraints, low production volumes, limited infrastructure and insufficient external funding, etc. since the case discussed here is of MSMEs working on flexographic printing, the machinery involved in the production is very costly, and most imported from other countries. They also require huge facility areas, which hinders the success of these firms.

The limitation of this research work is that the proposed model is based on expert opinion, which may contain some bias. Therefore, the model given here needs to be statistically validated, which can be done with the help of various statistical techniques such as structural equation modeling etc.

This interrelationship model is developed for the flexographic printing industry. This finding can be used for research in any other industry. MSMEs working on flexographic printing suffer a lot due to the competition from global leaders and the production of defective labels leading to the loss of goodwill, which can be an area of improvement in the future.

Conflict of Interest

The authors confirm that there is no conflict of interest to declare for this publication.

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